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A Review on the Influence of Input Parameters in Turning Process

Parvinder Singh[1,] *, A. S. Channi[1]

[1] *Department of Mechanical Engineering, Yamuna Institute of Engineering & Technology, Yamuna Nagar, Haryana, India.*

* Corresponding author. E-mail: psparvinder85@gmail.com (Parvinder Singh)

Abstract

The present research article has attempted to study the several process parameters in turning process and also to critically review the influence of variables over the different process responses. In available literature, turning of distinct engineering materials namely; AISI tool steel, mild steel, stainless steel, glass polymer fiber composites, etc. have been attempted as reported. Various studied input variables are; feed rate, spindle speed, depth of cut, tool nose radius, coolant types used, machining conditions (dry and wet), etc. Feed rate and depth of cut have been observed to influence various machining responses such as; thrust force, material removal rate, surface roughness, feed force, etc. significantly.

Keywords: Review; material removal rate; spindle speed; turning operation; depth of cut.

1. Introduction

Metal cutting is one of the most important methods of removing unwanted material in the production of mechanical component. Metal cutting is the process of producing a job by removing a layer of unwanted material from a given work pieces. Figure 1 show the schematics of a typical metal cutting process in which a wedge shaped, sharp edged tool is set to certain depth of cut and moves relative to the work piece.

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters.

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

- With the work piece rotating.
- With a single-point cutting tool, and
- With the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

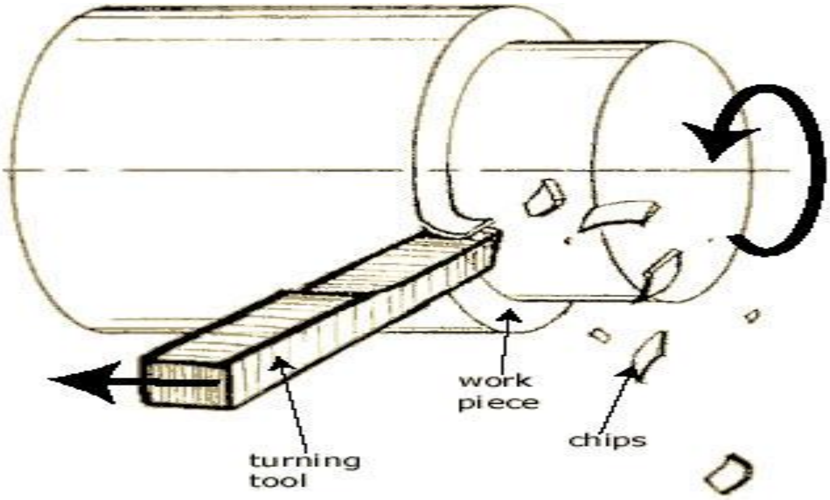

Figure 1: Process of turning operation (Young & Trang, 1997).

2. Literature review

A lot of research work has been carried out on turning of different engineering materials with a view to assess the effect of process variables on machining outputs.

Singh (2006) reported the optimization of process parameters for turning EN24 steel bars, using spindle speed, depth of cut and feed rate as controlled factors and feed force as response variable through the Taguchi approach. Ozel (2005) conducted an experimental investigation using steel work piece, spindle speed, work piece length and cutting tool material control parameters and surface roughness as response parameter. Results show that the effect of spindle speed on the surface roughness is most significant, the effect of cutting tool material is less significant and especially, small work piece length result in better surface roughness.

Singh (2005) attempted to review the optimizing machining parameters in turning process reported an optimal setting of process parameters. Various conventional techniques employed for optimization include geometric programming, geometric plus liner programming, goal programming, dynamic programming etc. The latest technique for optimization includes fuzzy logic, scatter search technique, genetic algorithm, Taguchi's technique and response surface methodology. Kataria and Kumar (2014) performed the multi response optimization in turning process. Bhattacharya (2008) estimated the effect of cutting parameters on surface finish and power consumption during high speed machining of AISI 1045 steel using Taguchi design and ANOVA. The result showed a significant effect of cutting speed on the surface roughness and power consumption while the parameters did not substantially of affect the response.

Zhou (1995) investigated the tool life criteria in raw turning. A new tool-life criterion depending on a pattern-recognition technique was proposed and neural network and wavelet techniques were used to realize the new criterion. The experimental results showed that this criterion was applicable to tool condition monitoring in a wide range of cutting conditions. Singh and Singhal (2016) carried out a review on the machining with hybrid approaches. Choudhary and Bartarya (2003) focused on design of experiments and the neural network for prediction of tool wear. The input parameters were cutting speed, feed and depth of cut; flank wear, surface finish and cutting zone temperature were selected as outputs. Empirical relation between different responses and input variables and also through neural network (NN) program helped in predictions for all the three response variables and compared which method was best for the prediction.

Table 1: Summary of Literature Work carried out on turning process.

Sr. No.	Author(s)	Process variables	Work material	Method used
1	Thamizhmainil (2006)	Cutting speed, Depth of cut and ,Feed	SCM440 Alloy steel	Taguchi method
2	Bhattacharya (2008)	Cutting speed, Depth of cut and ,Feed	AISI 1045 steel	Taguchi design and ANOVA
3	Philip (2010)	Cutting speed, Depth of cut and ,Feed	AISI 304	Taguchi design and ANOVA
4	Mahapatra (2006)	Cutting speed, Depth of cut and ,Feed	S45 C	Taguchi design method
5	Bouacha (2010)	Cutting speed, Depth of cut and ,Feed	AISI 52100 hardened steel	Response surface methodology
6	Yang and Trang (1998)	Cutting speed, Depth of cut and ,Feed	S45C	Taguchi method
7	Noordin 2004	Cutting speed, feed rate, and side cutting edge angle	AISI 1045 steel	Response surface methodology
8	Nain (1998)	Cutting speed, Depth of cut and feed rate,	S45C	Taguchi technique
9	Kaladhar (2010)	Cutting speed, Depth of cut, feed rate and noise radius	AISI 202 austenitic stainless steel	Full factorial Design
10	Parsad (2009)	Cutting speed, Depth of cut and feed rate,	En31	DOE

Feng and Wang (2002) investigated for the prediction of surface roughness in finish turning operation by developing an empirical model through considering working parameters: work piece hardness (material), feed, cutting tool point angle, depth of cut, spindle speed, and cutting time. Data mining techniques, nonlinear regression analysis with logarithmic data transformation were employed for developing the empirical model to predict the surface roughness. Thamizhmanii (2007) applied Taguchi method for finding out the optimal value of surface roughness under optimum cutting condition in turning SCM 440 alloy steel. The experiment was designed by using Taguchi method and experiments were conducted and results thereof were analyzed with the help of ANOVA (Analysis of Variance) method. The causes of poor surface finish as detected were machine tool vibrations, tool chattering whose effects were ignored for analyses. The authors concluded that the results obtained by this method would be useful to other researches for similar type of study on tool vibrations, cutting forces etc. The work concluded that depth of cut was significant factor which contributed to the surface roughness.

Ozel (2007) carried out finish turning of AISI D2 steels (60 HRC) using ceramic wiper (multi-radii) design inserts for surface finish and tool flank wear investigation. For prediction of surface roughness and tool flank wear multiple linear regression models and neural network models were developed. Neural network based predictions of surface roughness and tool flank wear were carried out, compared with a non-training experimental data and the results thereof showed that the proposed neural network models were efficient to predict tool wear and surface roughness patterns for a range of cutting conditions. The study concluded that best tool life was obtained in lowest feed rate and lowest cutting speed combination. Nes et al. (2010) studied the influence of tool geometry on the surface finish obtained in turning of AISI 1040 steel. In order to find out the effect of tool geometry parameters on the surface roughness during turning, response surface methodology (RSM) was used and a prediction model was developed related to average surface roughness (Ra) using experimental data. The results indicated that the tool nose radius was the dominant factor on the surface roughness. In addition, a good agreement between the predicted and measured surface roughness was observed. Therefore, the developed model can be effectively used to predict the surface roughness on the machining of AISI 1040 steel within 95% confidence intervals ranges of parameters studied. Singh et al. (2015) performed the machinability study in ultrasonic machining of titanium alloy. Nian et al. (1998) reported about the optimization of turning operations based on the Taguchi method with multiple performance characteristics is proposed the orthogonal array, multi-response signal-to-noise ratio, and analysis of variance are employed to study the performance characteristics in turning operations. Three cutting parameters namely, cutting speed, feed rate, and depth of cut, are optimized with considerations of multiple performance characteristics including tool life, cutting force, and surface roughness. Experimental results are provided to illustrate the effectiveness of this approach. Figure 2 shows the cause and effect diagram for turning process.

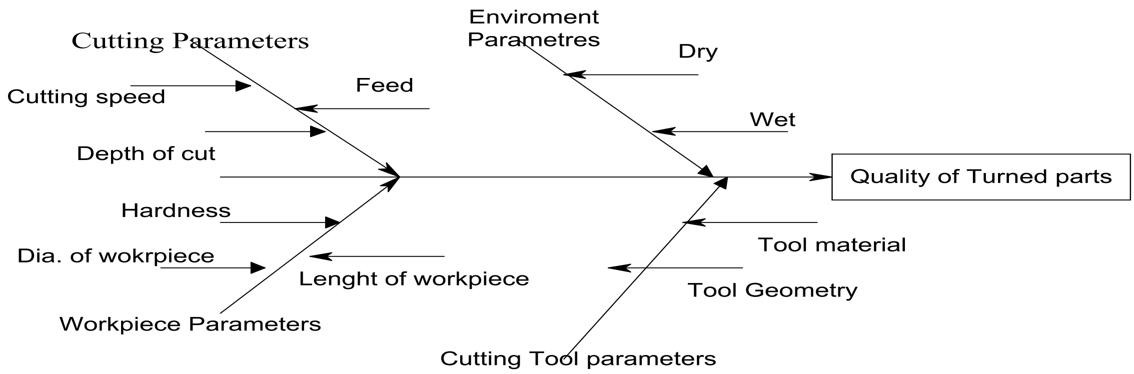

Figure 2: Cause and effect diagram.

Daniel et al. (2007) discussed the development of a surface roughness prediction system for a turning operation, using a fuzzy nets modeling technique. The goal is to develop and train a fuzzy-nets-based surface roughness prediction (FN-SRP) system that will predict the surface roughness of a turned work piece using accelerometer measurements of turning parameters and vibration data. The FN-SRP system has been developed using a computer numerical control (CNC) slant-bed lathe with a carbide cutting tool. The system was trained using feed rate, spindle speed, and tangential vibration data collected during experimental runs. A series of validation runs indicate that this system has a mean accuracy of 95%. Kevin et al. (2003) observed that the

Tool nose radius effects on finish turning of hardened AISI 52100 steels. Surface finish, tool wear, cutting forces, and, particularly, white layer were evaluated at different machining conditions. Results show that large tool nose radii only give finer surface finish, but comparable tool wear compared to small nose radius tools. Specific cutting energy slightly increases with tool nose radius. For new tools, white layers only occur at aggressive feeds (0.3 mm/rev) and small nose radius results in deeper white layers. For worn tools, white layers appear even at mild feeds (0.05 mm/rev), but in contrast, large nose radius leaves deeper white layers. Smaller tool nose radius gives larger uncut chip thickness, and thus, greater shear plane heat source that may induce deeper white layers for new tool conditions. For worn tools, where the wear-land sliding is the major heat source, temperature analysis at machined surfaces reveals that the larger the tool nose radius, the deeper the temperature penetration due to a shorter transition-material zone from the cutting edge to the final machined surface

Lalwani et al. (2008) attempted has been made to investigate the effect of cutting parameters (cutting speed, feed rate and depth of cut) on cutting forces (feed force, thrust force and cutting force) and surface roughness in finish hard turning of MDN250 steel managing steel using coated ceramic tool. The machining experiments were conducted based on response surface methodology (RSM) and sequential approach using face centered central composite design. The results show that cutting forces and surface roughness do not vary much with experimental cutting speed in the range of 55–93 m/min. In the thrust force, feed rate and depth of cut contribute 46.71% and 49.59%, respectively. In the cutting force, feed rate and depth of cut contribute 52.60% and 41.63% respectively, plus interaction effect between feed rate and depth of cut provides secondary contribution of 3.85%. A non-linear quadratic model best describes the variation of surface roughness with major contribution of feed rate and secondary contributions of interaction effect between feed rate and depth of cut, second order (quadratic) effect of feed rate and interaction effect between speed and depth of cut. The suggested models of cutting forces and surface roughness adequately map within the limits of the cutting parameters considered. Yang et. al (1997); in this paper, the Taguchi method, is used to find the optimal cutting parameters for turning operations. An orthogonal array, the signal-to-noise (S:N) ratio, and the analysis of variance (ANOVA) are employed to investigate the cutting characteristics of S45C steel bars using tungsten carbide cutting tools. Murgugan (2009) found the optimum process parameters for end milling while hard machining of hardened steel. Kaladhar (2010) optimized the machining parameters in turning of AISI 202 Authentic stainless steel using CVD coated cemented carbide tool. The process parameters are speed, feed, depth of cut and nose radius. The response variable is the surface roughness. The full factorial design and ANOVA are used for analysis the result. It is observed from the result that the Feed rate is the most significant factor that influences the surface roughness.

3. Conclusions

Based on the literature survey conducted, the following conclusions can be made:

- The selection of input variables in turning process is highly crucial issue as it affects the process capability and effectiveness.
- Feed rate significantly affect the thrust force in turning of any material on the lathe machine. With regarding to the average response feed rate and depth of cut are more significant as compare to speed.

- Depth of cut significantly affects the surface roughness in turning process. Feed rate is the most crucial variable that affects the MRR in turning process.

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